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ABSTRACT

Two experiments made in a study of the feasibility of keeping children away from harmful household goods through the use of odorous chemical substances which elicit inherent aversive reactions in children are discussed. The subjects, procedure, and results of each experiment are given. The overall results of the study show that, in general, the preference scale for children is the same as that for adults. On that basis, it would be theoretically possible to select an odorant very unpleasant to adults and use it to code noxious substances so that children would avoid them. In the final analysis, it is suggested that one must continue to teach children to avoid noxious substances and should not rely on inherent defense mechanisms. (DB)

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Feasibility of Olfactory Coding of Noxious Substances to Assure Aversive Responses in Young Children

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THE INJURY CONTROL RESEARCH LABORATORY PERFORMS EXPERIMENTAL analyses of a person's ability to detect and appreciate hazards in his environment and protect himself from injury. Through systematic variation of the pertinent organismic and environmental variables, behavioral scientists and engineers identify the factors that cause errors of perception or judgment that lead to accidents, and assess the effectiveness of countermeasures intended to control these factors.

FOR INFORMATION ABOUT THE LABORATORY OR OTHER ASPECTS OF THE Injury Control Program write to the Director, Injury Control Research Laboratory, 235 Promenade Street, Providence, Rhode Island 02908, or to the Chief, Division of Planning and Standards, 222 East Central Parkway, Cincinnati, Ohio 45202.

RESEARCH REPORT
ICRL-RR-69-6

October
1969

THIS RESEARCH REPORT IS CONCERNED WITH THE FEASIBILITY OF keeping young children away from harmful household products by the addition of odorous chemical substances which elicit inherent aversive reactions in the children. It is an extension of the concern in the Injury Control Research Laboratory with the utility of tastes and smells as hazard indicators.

THIS REPORT WILL BE OF INTEREST TO PUBLIC HEALTH OFFICIALS, those concerned with product safety and accident prevention, and scientists performing research on the maturation and socialization of the olfactory senses.

THE REPORT HAS IMPLICATIONS FOR INJURY CONTROL PARTICULARLY BY indicating the tolerance of children under seven for odors that are noxious to the adult.

THIS REPORT AND THE RESEARCH DESCRIBED THEREIN WAS DONE BY TWO psychologists in the Department of Psychology at Brown University under a contract monitored by the Injury Control Research Laboratory. The principal investigator, Dr. Trygg Engen, Professor of Psychology at the University, is internationally known for his work on the chemical senses. His associate on this study, Dr. Tiina Corbit, received her doctorate in 1969 under the direction of Dr. Engen. The study was planned and the report prepared by Dr. Engen. The data were collected by Dr. Corbit.

Final Report
UNITED STATES PUBLIC HEALTH SERVICE
CONTRACT PH 86–68–162
FEASIBILITY OF OLFACTORY CODING OF NOXIOUS SUBSTANCES TO ASSURE AVERSIVE RESPONSES IN YOUNG CHILDREN

The purpose of the present research was to study the feasibility of keeping children away from harmful household goods through the use of odorous chemical substances which elicit inherent aversive reactions in the children. The existence of such substances has been suggested by earlier studies. However, it has also been suggested that young children do not have strong aversive reactions to odorants. For example, Stein, Ottenberg, and Roulet (1) have reported a discontinuity in the affective reactions of four and five year old children to what they describe as synthetic odors of feces and sweat (but, unfortunately, do not identify further). In their study three and four-year old children tended to say they liked those odors, while children five years and older said they disliked them. The authors believe that this is ''related to early childhood experiences and to the mastery of instinctual impulses.'' (1 p. 265)

Moncrieff (2) also came to the conclusion that children seem to exhibit greater tolerance to unpleasant odors than adults. His subjects ranged from about seven to fifteen years of age and were presumably beyond the Oedipal stage, but they still rated compounds with a fecal olfactory note higher than did adults and more pleasant than the odors of oily smells which they seemed to dislike. Moncrieff takes a more general developmental approach and suggests that the tolerance of the children may diminish with maturation. Age, therefore, may be the most important consideration in understanding approach and avoidance behavior in the case of olfactory stimuli,

S 3

although it is not clear whether the olfactory mechanism or the learned preferences, or both, change with age.

Such findings would seem to be contrary to the goal of the present research of finding odorants to which children would show a low tolerance. However, before one can reach a conclusion on this basic question, it is necessary to deal with an important methodological problem. An earlier study of judgment of odor preferences by Kniep, Morgan, and Young (3) concluded that there was good agreement in the results obtained from children (age 7-9) but that there were doubts about the reliability of the childrens' judgments. An unpublished study by Engen and Katz (4) suggested the possibility that the most important change with age is not in odor preference but in the tendency to acquiesce, that is, for a child to agree when asked by an adult whether an odor smells good (or bad) regardless of its actual hedonic value. Such "false positives" apparently depend on both the form of the question and the age of the child.

Since all previous studies of odor preference in children have been subject to such verbal biases, the very first experiment with the present purpose of sensory coding of noxious substances must eliminate verbal responses, arrange for observation of actual choices made by children, and compare such choices with those made by adults. The present study consists of two experiments. In the first the odorants were matched in subjective intensity in order that choices be obtained on the basis of differences in odor quality rather than intensity. In the second experiment, which is of main interest, the hedonic values, that is, like versus dislike, of these matched odorants were scaled with the method of pair comparison. The odorants included neroli oil and rapeseed oil which Moncrieff (1968) suggests might be especially aversive to children.

Experiment 1

The first experiment was designed to match four odorants in psychophysical intensity.

Method

SUBJECTS

The following five odorants were used in the present experiment. Except for rapeseed oil, they were obtained from Fritzsche, Dodge & Olcott, Inc.

1) Rapeseed oil is a plant oil that smells like castor oil. It is used in the manufacture of margarine and soft soaps. The present sample was obtained from Welch, Holme and Clark Co., Inc.

2) Butyric acid is obtained by fermenting carbohydrates and is used in the manufacture of sodas and candy and is presumably responsible for the odor of rancid butter.

3) Neroli oil is an oil from orange blossoms used in perfume and food flavoring.

4) Safrole is an oil of the sassafras root with the odor of licorice and is used in perfumes.

5) Diethyl phthalate, an almost odorless oily solvent often used as a diluent by perfumers, was the fifth odorant. It was expected that it would be in the neutral zone and was used as a kind of control stimulus for the hedonic judgments. D.p. was also used as the diluent for the test odorants. None of these five odors is harmful to children.

Rapeseed oil, the weakest odorant of the four test odorants was used at full strength as the standard stimulus. A series of ten concentrations, equally spaced on a logarithmic scale, was made of each of the three comparison odorants—butyric acid, neroli oil and safrole. (Diethyl phthalate was used as the diluent.) The range of concentrations of each odorant was determined on the basis of judgments made by two observers with two preliminary concentration series, and was chosen to span the perceived intensity of the standard stimulus.

One ml. of each odorant stimulus was placed in a 10 by 75 mm. pyrex test tube. A glass rod wrapped with cotton, attached to a cork wrapped in aluminum foil, was inserted into each test tube. The cork sealed the test tube and was removed, with the glass rod, only for sniffing the odorant stimulus.

PROCEDURE

The subject was seated at a table and was presented with a rack containing eight test tubes of one comparison series arranged in order of ascending concentration and one test tube containing the standard stimulus. The subject was instructed to sniff the standard, then sniff the weakest stimulus in the comparison series, and judge whether the comparison stimulus was stronger, weaker or of the same intensity as the standard. This procedure was repeated at 15 sec. intervals with successive numbers of the comparison series until the subject was confident

that he had found a stimulus which matched the standard stimulus in intensity. The subject was allowed to descend the series if he thought he had exceeded the intensity of the standard, and to "bracket" around the appropriate concentration of the comparison stimulus.

Each subject completed six such ascending series, two with each comparison series, with two minute rests between series. The first three series consisted of the three comparison odorants, presented in all possible orders to different subjects. The last three series of a session were presented in reverse order—thus a subject who received butyric acid, safrole, and neroli oil, respectively, as his first three series, received neroli oil, safrole and butyric acid as his fourth, fifth and sixth series. Four subjects received stimuli one to eight (with stimulus one the strongest in the series) of each comparison series on the first presentation of each series, and stimuli three to ten on the second presentation. The remaining five subjects received stimuli three to ten on the first presentation and stimuli one to eight on the second presentation.

Results

Table 1 shows the number of times that each concentration of the three comparison odorants was judged to match the standard, 100%, rapeseed oil, in intensity. Since all subjects judged each comparison series twice, there is a total of 18 judgments for each comparison odorant. The median judgment of each series was taken as the concentration which matched the standard in psychophysical intensity. These median concentrations are underlined in Table 1 and are assumed to represent approximately equal psychophysical intensities. One subject judged all concentrations of butyric acid to be stronger than the standard, and thus her two judgments are entered in Table 1 as greater than ten.

Experiment 2

This experiment was designed to obtain scales of preference for the odorants matched in Experiment 1 plus diethyl phthalate for various age groups, including adults.

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Table 1

Concentrations (per cent volume in diethyl phthalate) of comparison odorants judged to be approximately equal in psychophysical intensity to standard (100% rapeseed oil). Underlined values represent median judgments

Stimulus number	Safrole % Concentration	Safrole No. of times judged equal to standard	Neroli oil % Concentration	Neroli oil No. of times judged equal to standard	Butyric acid % Concentration	Butyric acid No. of times judged equal to standard
1	50.0	0	17.5	0	6.25	0
2	35.0	2	12.5	0	4.375	0
3	25.0	0	8.75	2	3.125	1
4	17.50	5	6.25	0	2.188	1
5	12.50	1	4.375	3	1.563	0
6	8.75	3	3.125	9	1.094	3
7	6.25	6	2.188	2	0.781	6
8	4.375	1	1.563	1	0.547	2
9	3.125	0	1.094	1	0.391	3
10	2.188	0	0.781	0	0.274	0
> 10						
		18		18		2/18

Method

SUBJECTS

Four year old subjects were obtained from Lincoln Nursery School, a private school in Providence, Rhode Island, and five to seven year old subjects were obtained from Martin Luther School, a public school in Providence. Undergraduate students at Brown University were the adult subjects. Table 2 presents the mean age, range, and number (N) of subjects in each of the five groups. All subjects were tested in their respective schools and none appeared to be suffering from colds or other conditions which might interfere with odor perception, although medical screening was not feasible.

Table 2

Age group (N)	Mean age (N)*	Range
4 year olds (28)	4 yr. 7 mo. (28)	12 mo.
5 year olds (28)	5 yr. 7 mo. (28)	10 mo.
6 year olds (28)	6 yr. 5 mo. (15)	13 mo.
7 year olds (28)	7 yr. 5 mo. (27)	13 mo.
adults (28)	18 yr. (28)	6 yr.

*Birthdates were not available for all subjects and therefore calculations of mean age and range are not based on all subjects.

MATERIALS

The odorants were diethyl phthalate (undiluted), 0.718% butyric acid, 3.125% neroli oil, rapeseed oil (undiluted), and 8.75% safrole.

DESIGN AND PROCEDURE

The ten pairs of these five odorants (excluding identical pairs) were presented such that each of the five odorants was paired with every other odorant equally often and in a balanced series. Any one odorant was presented first in two of the pairs and second in the other pairs. Subjects in each age group were randomly assigned to one of the four subgroups. A random order of pairs was determined for the first subgroup (pair 1 to pair 10). The order of stimuli within pairs was reversed for the second subgroup. Finally, the third and fourth subgroups

received the pairs in the reverse order (pair 10 to pair 1). In addition, the first stimulus pair was repeated at the end of the series to provide an estimate of the reliability of the responses.

The subject was seated across a table from the experimenter, who kept the stimuli out of view until ready for presentation. Each stimulus was presented on a glass rod wrapped with cotton saturated with odorant. On each trial, a pair of stimuli kept in test tubes was placed in a rack before the subject, and he was instructed to sniff them in order. The subject was instructed to take a good sniff of each odorant from the cotton as the experimenter held each member of the pair under his nose and then point to the one he ''liked best.'' There was an interval of approximately five seconds between the members of each pair of stimuli, and sixty seconds between pairs.

Results

Table 3 indicates that, as measured by the number of times the same choice was made on the first (at the beginning) and second (at the end of the session) presentation of the same pair, the judgments obtained are stable and warrant further analysis. It is interesting to note that for the children this index is nearly the same for all age groups, but that it is much higher for the group of adult subjects. This difference does not directly affect the comparison made below, but it is apparently a general problem and must be borne in mind in comparing the judgments of adults and children.

Table 3

Reliability of choices—the number of times the choice was the same or different on trials 1 and 11

Age group	Same	Different
4 year olds	18	8
5 year olds	18	10
6 year olds	21	7
7 year olds	20	8
adults	26	2

Table 4 A–E shows the basic results of Experiment 2 which are proportions of the subjects in each group choosing one odorant over another of the four odorants. These proportions are obtained by dividing the number of four year olds who preferred, for example, rapeseed oil to butyric acid by the total number of subjects in the group. This value is .538 and is entered in the second column of the first row of Table 4A. The proportion who preferred butyric acid to rapeseed oil is shown in the first column of the second row.

In this raw form the data make possible only comparison between pairs. By making use of the known relationship between proportions under the normal curve and so-called z-scores or standard scores for which the mean is always zero and the standard deviation 1 one can make more general comparisons of the results within each group as well as between groups. Scores below the mean (for the minority vote) will then be negative and scores above the mean (the majority vote) will be positive in sign. According to Thurstone's Law of Comparative Judgment (See Torgerson, 5) it is assumed that the psychological preference values for the different individuals are normally distributed and that z-scores thus represent the psychological distance between these preference values for different odorants. In other words, the z-scores show the location of a score in a distribution.

Table 5 A–E shows the z-scores (psychological distances) between pairs of odorants corresponding to the proportions in Table 4 A–E. In addition to the direct estimate of the distance between each pair of odorants (e.g., –.10 for rapeseed oil and butyric acid), there are three indirect estimates of this distance because each member of that pair was also compared with each of the three other odorants used in the experiment. Therefore the best estimate of the psychological value based on all the information from each group is obtained by taking the mean of the values in each column in Table 5 A–E. These means are relative scale values with an arbitrary unit on a psychological continuum of preference, according to Case V of Thurstone's Law of Comparative Judgments. It must be borne in mind that these values do not give any information about absolute hedonic values of the odorants, and that the possibility, for example, that children give higher (or lower) pleasantness ratings in general than adults cannot be determined from these data.

Table 4. PROPORTION OF CHOICES OF ODORANTS

Each entry is the proportion of subjects preferring the odorant in the row to the corresponding odorant in the column on the left. Each matrix gives the results for a different age group. (Note that the entries below the diagonal are reciprocals of those above the diagonal).

A Four Year Olds (N = 29)

	Butyric acid	Rapeseed oil	Diethyl phthalate	Neroli oil	Safrole
Butyric acid	.500	.538	.731	.731	.808
Rapeseed oil	.462	.500	.692	.462	.615
Diethyl phthalate	.269	.308	.500	.538	.538
Neroli oil	.269	.538	.462	.500	.731
Safrole	.192	.385	.462	.269	.500

B 5 Year Olds

Butyric acid	.500	.786	.750	.750	.821
Rapeseed oil	.214	.500	.643	.464	.714
Diethyl phthalate	.250	.357	.500	.393	.607
Neroli oil	.250	.536	.607	.500	.643
Safrole	.179	.286	.393	.357	.500

C 6 Year Olds

Butyric acid	.500	.786	.821	.786	.929
Rapeseed oil	.214	.500	.679	.750	.679
Diethyl phthalate	.179	.321	.500	.607	.786
Neroli oil	.214	.250	.393	.500	.536
Safrole	.071	.321	.214	.464	.500

D 7 Year Olds

Butyric acid	.500	.750	.857	.893	.893
Rapeseed oil	.250	.500	.750	.750	.821
Diethyl phthalate	.143	.250	.500	.500	.607
Neroli oil	.107	.250	.500	.500	.714
Safrole	.107	.179	.393	.286	.500

E Adults

Butyric acid	.500	.857	.964	(.995)	(.955)
Rapeseed oil	.143	.500	.929	1.000	1.000
Diethyl phthalate	.036	.071	.500	.750	.857
	(.005)			.679	.857
Neroli oil	0	.250	.321	.500	.679
Safrole	0	.143	.143	.321	.50

Table 5

A Four Year Olds

z-scores for pairs of odorants based on the proportions in Table 4 A–E

	Butyric acid	Rapeseed oil	Diethyl phthalate	Neroli oil	Safrole
Butyric acid	0.	.10	.61	.61	.88
Rapeseed oil	− .10	0.	.50	− .10	.31
Diethyl phthalate	− .61	− .50	0.	.10	.10
Neroli oil	− .61	.10	− .10	0.	.61
Safrole	− .88	− .31	− .10	− .61	0.
Σ	− 2.20	− 0.61	+ 0.91	0	1.90
Mean	− 0.55	− 0.15	+ 0.23	0	+ 0.48

B 5 Year Olds

Butyric acid	0	.81	.67	.67	.92
Rapeseed oil	− .81	0	.36	− .10	.55
Diethyl phthalate	− .67	− .36	0	− .28	.28
Neroli oil	− .67	.10	.28	0	.36
Safrole	− .92	− .55	− .28	− .36	0
Σ	− 3.07	0	+ 1.03	− .07	+ 2.11
M	− 0.77	0	+ 0.26	− 0.02	+ 0.53

C 6 Year Olds

Butyric acid	0	.81	.92	.81	1.48
Rapeseed oil	− .81	0	.47	.67	.47
Diethyl phthalate	− .92	− .47	0	.28	.81
Neroli oil	− .81	− .67	− .28	0	.10
Safrole	− 1.48	− .47	− .81	− .10	0
Σ	− 4.02	− 0.80	+ 0.30	+ 1.66	+ 2.86
M	− 1.00	− 0.20	+ 0.08	+ 0.42	+ 0.72

Table 5 (Cont'd)

D 7 Year Olds

	Butyric acid	Rapeseed oil	Diethyl phthalate	Neroli oil	Safrole
Butyric acid	0	.67	1.08	1.23	1.23
Rapeseed oil	- .67	0	.67	.67	.92
Diethyl phthalate	- 1.08	- .67	0	0	.28
Neroli oil	1.23	- .67	0	0	.55
Safrole	- 1.23	- .92	- .28	- .55	0
Σ	- 4.21	- 1.59	+ 1.47	+ 1.35	+ 2.98
M	- 1.05	- 0.40	+ 0.37	+ 0.34	+ 0.74

E Adults

Butyric acid	0	1.08	1.75	2.58	2.58
Rapeseed oil	- 1.08	0	1.48	.67	1.08
Diethyl phthalate	- 1.75	- 1.48	0	.47	1.08
Neroli oil	- 2.58	- .67	- .47	0	.47
Safrole	- 2.58	- 1.08	- 1.08	- .47	0
Σ	- 7.99	- 2.15	1.68	3.25	+ 5.21
M	- 2.00	- 0.54	+ 0.42	+ 0.81	+ 1.30

It is clear that the relative differences in the hedonic values are smaller for children than for adults. This is shown clearly in Table 6 which summarizes the scales obtained in the different parts of Table 4. Children do not discriminate as well between odorants on an hedonic or preference scale as do adults. The older the group the more their scale values agree with those obtained for adult subjects. This can be seen most clearly by comparing the range of scale values for each group, presented in the last column of Table 6.

Table 6

Thurstone Case V scale values for five odorants from five different age groups

Age group	Butyric acid	Rapeseed oil	Diethyl phthalate	Neroli oil	Safrole	Range
4	- 0.55	- 0.15	+ .023	0	+ 0.48	1.03
5	- 0.77	0	+ 0.26	- 0.02	+ 0.53	1.30
6	- 1.00	- 0.20	+ 0.08	+ 0.42	+ 0.72	1.77
7	- 1.05	- 0.40	+ 0.37	+ 0.34	+ 0.74	1.79
Adult	- 2.00	- 0.54	+ 0.42	+ 0.81	+ 1.30	3.30

In general, the order of preferences of these five odorants from least to most preferred is, as expected, butyric acid, rapeseed oil, diethyl phthalate, neroli oil, and safrole. It is interesting to note that a weak and nondescript odor like diethyl phthalate, which is used as a diluent because it is nearly odorless, is near the neutral or zero point, but it is judged as relatively pleasant. Table 6 shows also that for age groups 4 and 5 the ordering of rapeseed oil, diethyl phthalate, and neroli oil in the neutral zone, around zero, of this scale is different from the adult ordering, but that for the older groups of children there is agreement with the adult subjects except for a slight reversal in the values of diethyl phthalate and neroli oil for the seven year old subjects.

Discussion

The results show that in general the preference scale for children is the same as that for adults. On that basis it would be theoretically possible to select an odorant very unpleasant to adult observers and use it to code noxious substances in order that children would avoid them. However, the data also show clearly that the difference in values on the scale for the

same odorants becomes smaller and smaller the younger the children. That means that the value of such sensory coding would be the least where it might be most needed.

Moncrieff (2) has suggested that children find all odors more pleasant than adults and, in general, are more tolerant of odors. The present data do not reject this hypothesis. It is possible that the scale values obtained by the children are shifted toward the pleasant end of the continuum relative to the scale values obtained by adults, although the relative placements of the odorants are the same for children and adults. There is no evidence from the present study, or any other, which makes it possible to decide this question of the absolute hedonic value. The children in this study did prefer butyric acid, which is highly unpleasant to adults, over considerably more pleasant odors in such high proportions as to suggest they would *not* avoid such an odor. However, logically it can only be concluded that the relative differences in the pleasantness or unpleasantness between odors are smaller for children than adults.

It seems more likely now than before this study that young children do not respond differentially to the hedonic attributes of odors which for adults form one of the most extensive and effective stimulus dimensions (Engen and McBurney, 6). This kind of discrimination depends on age. Barring chemical irritation and trigeminal stimulation, it is possible that there are no inherently unpleasant odors and that hedonic responses are acquired only as the result of experience with food, sex, and cultural values. Perhaps children first learn what to say about odors from adults and on that basis develop more profound likes and dislikes. It is suggested, therefore, in the final analysis that one must continue to teach children to avoid noxious substances and that, at least for the present, one may not rely on inherent defense mechanisms.

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